

SALINITY RELATIONS OF SOME FISHES IN THE ARANSAS RIVER, TEXAS¹

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INTRODUCTION

Fishes inhabiting bays and estuaries along the lower Gulf coast of Texas are at times subject to extremes in temperature and salinity. During droughts evaporation is high and salinity tends to increase during most months of the year. A question often discussed is: What part does salinity play in affecting distribution and abundance of fishes inhabiting this area?

Several workers have studied salinity relations of fishes in the inshore waters along the eastern and southern coasts of the United States. Hildebrand and Schroeder (1928) studied the fishes of Chesapeake Bay and included salinity records in many of their observations. Gunter (1945) published an extensive account of the distribution of the marine fishes of Texas as related to salinity. Gunter (1950) studied distribution and abundance of fishes in marginal ponds and salt flats in the Aransas National Wildlife Refuge with emphasis on changes due to temperature and salinity. The latter two studies were made during periods of normal or above normal rainfall. Simpson and Gunter (1956) described the effects of salinity on Gulf coast cyprinodonts during an extremely dry period. Simmons (1957) studied the problem in the usually hypersaline Laguna Madre of Texas.

Reid (1954) surveyed ecological relations of the fishes near Cedar Key, Florida. Reid (1955, 1956, 1957) published accounts of the changes in abundance and distribution of fishes in East Bay, Texas, before and after construction of an artificial pass connecting the blind end of that bay with the Gulf of Mexico. Kilby (1955) studied the fishes of Cedar Key and Bayport, Florida, and the extent to which salinity affected their distribution. Bailey, Winn, and Smith (1954), in their accounts of the fishes of the Escam-

bia River, Alabama and Florida, recorded salinity relations of many marine and freshwater fishes. Because abrupt salinity stratification occurred in the Escambia River at times, Bailey *et al.* (1954) were not always able to determine the exact salinity in which some of their specimens were living. Springer and Woodburn (1960) discussed the effects of salinity, temperature, and vegetation on the distribution of fishes in the Tampa Bay area.

The objective of this study was to note the occurrence of fishes found at three stations on the Aransas River under conditions of varying salinities. The study began during September 1956 at the height of one of the worst droughts ever recorded for this section of the United States. Field work was concluded in November 1957, six months after the drought was broken by heavy rains which fell during the summer of 1957. Two aspects which previous authors have not had an opportunity to study extensively are emphasized in this paper. First, the populations sampled came from habitats in which salinity was an important variable. Secondly, variation in salinity occurring in the river provided opportunities for study of the interaction of freshwater and marine fishes.

DESCRIPTION OF THE AREA

The Aransas River has its source at approximately latitude 28°17'N. and longitude 97°40'W. It terminates at Copano Bay, which is connected to the Gulf of Mexico through Aransas Bay and Aransas Pass (fig. 1). Except for drainage of water after rains there is no net seaward flow. Water stands only in the lower 28 miles of the river bed as the result of ground water addition and backup of water from the secondary bays. The river averages 100 feet in width and about 3 feet in depth although occasional deep holes may range to a depth of 15 feet.

Vegetation in the river was scanty, probably as a result of extremes in salinity. Along certain stretches of the banks were

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found emergent plants such as sedges, water hyssops, willows, rushes, grasses, and pondweeds. Dominant algae were a blue-green alga, *Phormidium* sp., and a green alga, *Cladophora* sp. The amount of this algal vegetation increased during the latter half of 1957 with the advent of increased precipitation and lowered salinities.

Salinity of the river appeared to be controlled by: (1) precipitation, (2) evapora-

METHODS

Stations were sampled every 4 to 6 weeks at which time air temperature, water temperature, weather conditions, and vegetation were observed. Samples of water to be measured for salinity were taken at the surface and at a depth of 2 feet. Salinity was determined by titration with silver nitrate. Table 2 summarizes temperature-salinity conditions observed at the three stations.

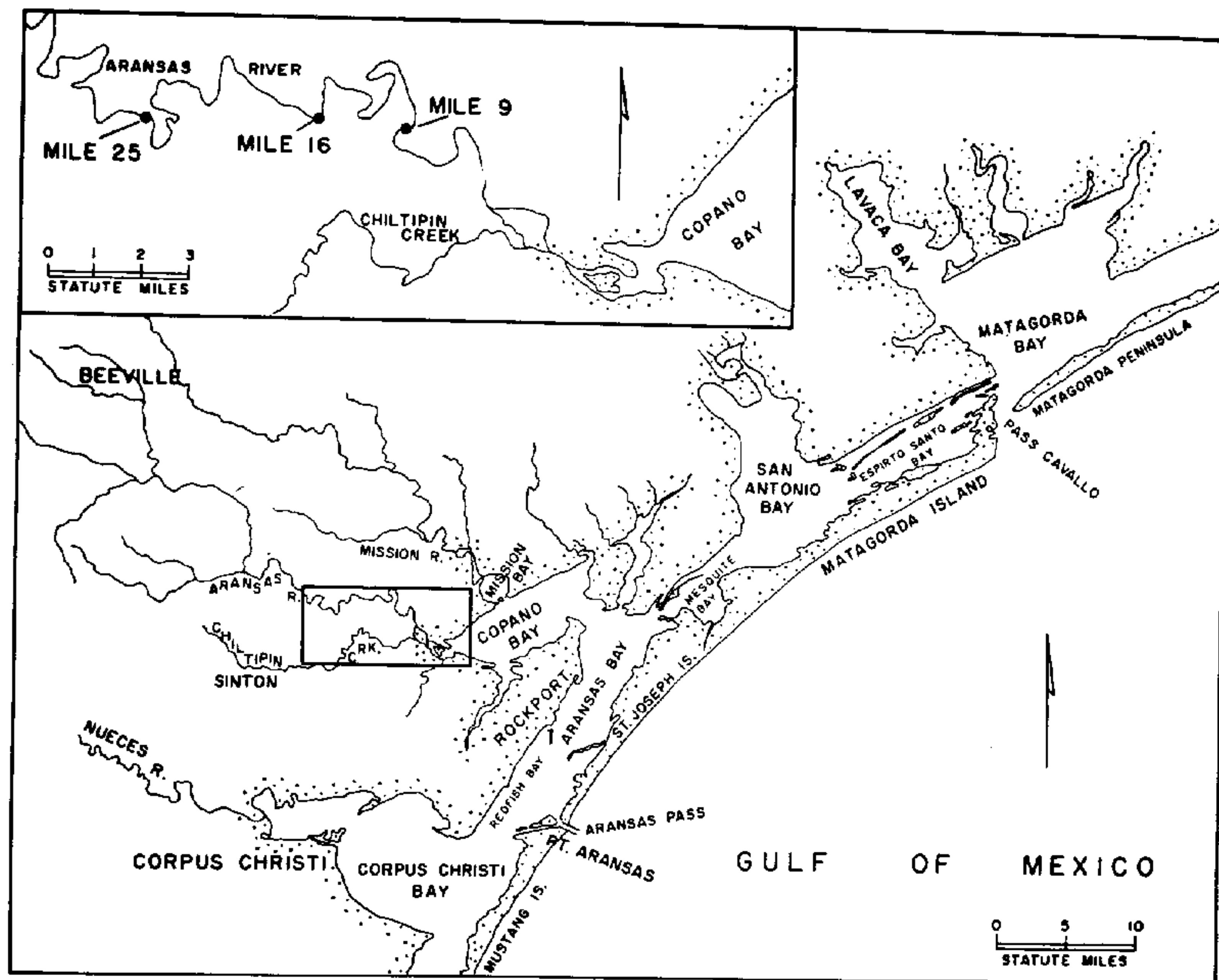


Figure 1. Central Texas coast showing location of study area.

tion, (3) intrusion of salt water from Copano Bay, (4) invasion of highly saline water from Chiltipin Creek which was polluted with brine wastes from oil fields. Salinities found at each station during the study are shown in Figure 2. Precipitation was recorded at Beeville, Texas, which lies in the middle of the watershed. Figure 2 shows that small amounts of rainfall merely dilute the saline water in the river while periods of heavy rainfall cause floods which flush it into the bays.

During April, May, and June 1957 the two lower stations were not sampled due to impassable roads.

No attempt was made to sample all fish species present in the river. The data presented concern only those fishes which could be sampled within a limited area and depth along the shore. The same 30-foot bag seine was used for all collections. It was 4 feet high with wings of $\frac{1}{3}$ -inch bar mesh and bag of $\frac{1}{4}$ -inch bar mesh. At each station the seine was hauled either once or twice

parallel to the shore over fixed paths and distances. All fish taken at a station were immediately preserved in 10 percent formalin for subsequent examination. All measurements are standard lengths to the nearest millimeter. Table 1 summarizes the distribution by salinity of the fishes collected.

Stations at 9, 16, and 25 miles from the mouth of the river being most accessible were selected as collection sites (fig. 1). Mile 9 and Mile 25 had gently sloping bot-

toms. At Mile 16 the bottom sloped gently for about 8 feet, then more abruptly so that at a distance of 12 feet offshore the depth had increased to 6 feet. The bottom at all three stations consisted of silt and mud.

SALINITIES RECORDED FOR SPECIES OBSERVED

Lepisosteus spatula Lacépède, Alligator gar—Only three alligator gars were taken with the type of gear used although the

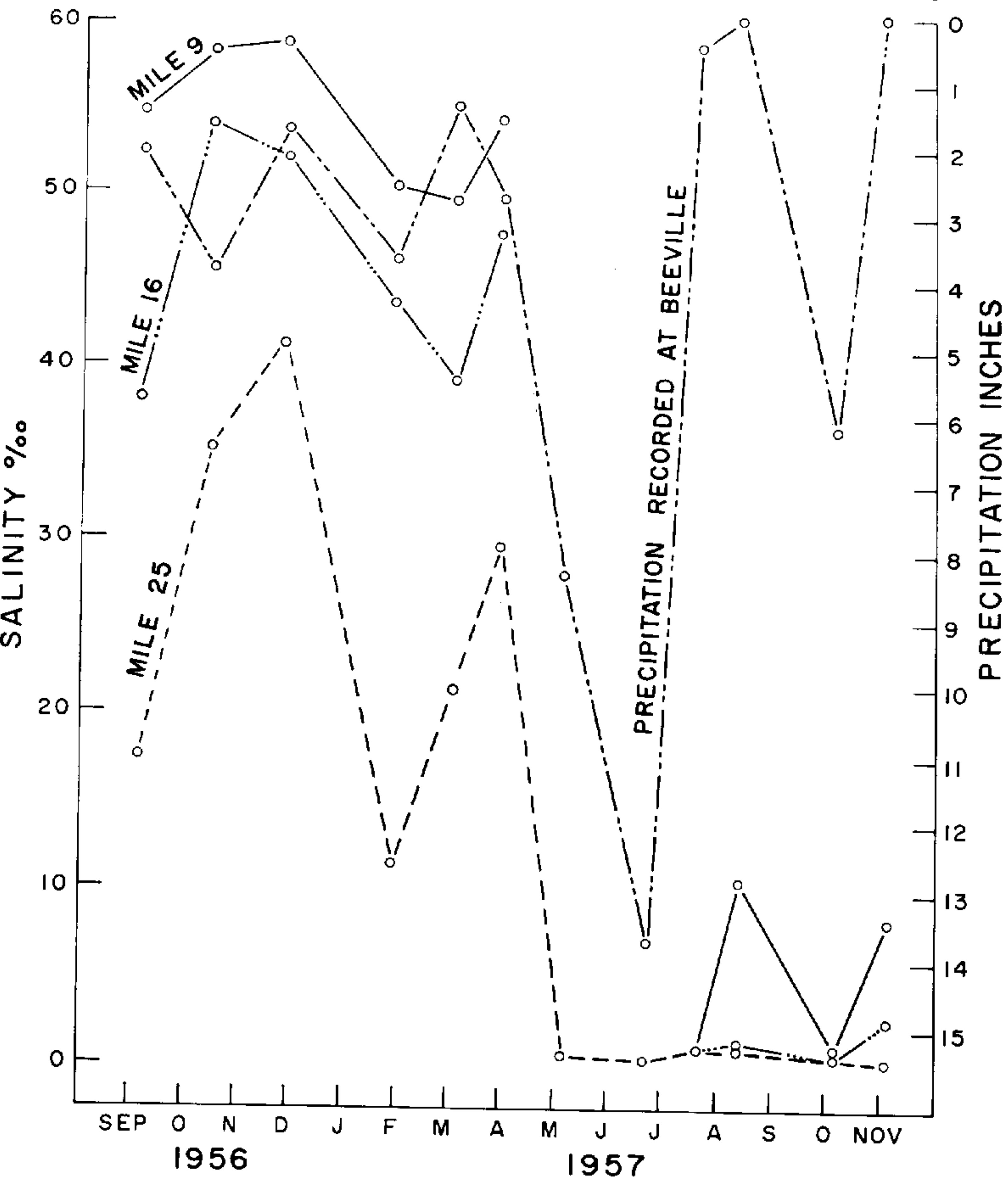


Figure 2. Salinity regimes—Aransas River. Precipitation at Beeville, Texas is the cumulative total recorded between collections.

species was abundant in the river at all times. One specimen approximately 1 meter long was captured at Mile 25 in October 1956 in a salinity of 35.2⁰/₀₀. Another was taken in October 1957 at Mile 25 in a salinity of 0.05⁰/₀₀. It measured 425 mm in length. The third was a small specimen 70 mm long collected in November 1957 in a salinity of 8.3⁰/₀₀ at Mile 9. Gars were observed in the river during every month of the year and in every salinity (0.05 to 58.6⁰/₀₀).

Brevoortia patronus Goode, Largescale menhaden.—One specimen 120 mm long was collected at Mile 9 in March 1957 in a salinity of 54.3⁰/₀₀. At the same time at Mile 16 another specimen measuring 32 mm was taken in 47.6⁰/₀₀. In July 1957 three individuals, 52, 61, and 64 mm long were found at Mile 16 in 0.5⁰/₀₀.

Dorosoma cepedianum (LeSueur), Gizzard shad.—Sixty specimens were collected in salinities ranging from 0.05⁰/₀₀ to 41.3⁰/₀₀. No juvenile fish were taken in the first half of the study when the river was highly saline. Forty specimens less than 40 mm long were caught in July 1957 in salinities of 1.1⁰/₀₀ or less. No small individuals were

taken in salinities above 1.1⁰/₀₀. This supports the conclusions of Gunter (1945) that the gizzard shad inhabiting coastal waters must return to fresh water to spawn. Only two adult gizzard shad were taken in highly saline water; one measuring 114 mm was caught in 35.2⁰/₀₀ and the other, 104 mm in length, was taken in 41.3⁰/₀₀.

Dorosoma petenense (Günther), Threadfin shad.—Thirty-three juveniles were collected. One specimen 35 mm in length was caught in a salinity of 10.4⁰/₀₀ at Mile 9 during August 1957. All others measured less than 60 mm in length and were taken in salinities of 1.0⁰/₀₀ or lower, indicating that this species also might require fresh water to spawn.

Anchoa mitchilli (Valenciennes), Bay anchovy.—A total of 228 individuals of this species was taken. They ranged from 23 to 57 mm in length although most were between 40 and 50 mm. Bay anchovies were found in salinities from 0.05⁰/₀₀ to 8.3⁰/₀₀ and none were taken during 1956 when the river was hypersaline.

Notropis lutrensis (Baird and Girard), Red shiner.—Three juveniles were collected in August 1957 in a salinity of 1.0⁰/₀₀.

TABLE 1.
Occurrence by salinity of fishes collected.

Salinity ⁰ / ₀₀	from: to :	.05 1.0	1.1 5.0	5.1 15.0	15.1 25.0	25.1 35.0	35.1 45.0	45.1 55.0	55.1 58.6
Collections in this salinity range		10	2	3	2	1	5	7	2
<i>Lepisosteus spatula</i>		1	—	1	—	—	1	—	—
<i>Brevoortia patronus</i>		3	—	—	—	—	—	2	—
<i>Dorosoma cepedianum</i>		47	5	6	—	—	2	—	—
<i>Dorosoma petenense</i>		32	—	1	—	—	—	—	—
<i>Anchoa mitchilli</i>		114	79	35	—	—	—	—	—
<i>Notropis lutrensis</i>		3	—	—	—	—	—	—	—
<i>Ictalurus furcatus</i>		1	—	1	—	—	—	—	—
<i>Syngnathus scovelli</i>		1	—	—	143	—	21	—	—
<i>Fundulus grandis</i>		8	—	11	2	—	4	17	2
<i>Lucania parva</i>		45	—	—	3	6	19	1	—
<i>Cyprinodon variegatus</i>		144	12	46	28	11	173	161	13
<i>Gambusia affinis</i>		22	6	1	4	—	—	—	—
<i>Mollienisia latipinna</i>		13	—	2	61	1	129	1	—
<i>Menidia beryllina</i>		285	124	75	302	484	137	77	7
<i>Mugil cephalus</i>		10	1	18	57	9	30	31	4
<i>Mugil curema</i>		1	—	—	—	—	—	—	—
<i>Micropterus salmoides</i>		—	—	—	1	—	—	—	—
<i>Chaenobryttus gulosus</i>		—	—	—	2	—	—	—	—
<i>Lepomis macrochirus</i>		41	8	—	6	—	—	—	—
<i>Lepomis megalotis</i>		4	—	—	—	—	—	—	—
<i>Bairdiella chrysura</i>		—	2	—	—	—	—	—	—
<i>Eucinostomus argenteus</i>		—	—	3	—	—	—	—	—
<i>Cichlasoma cyanoguttatum</i>		7	1	—	4	—	—	—	—
<i>Dormitator maculatus</i>		—	—	—	—	—	—	1	—
<i>Gobiosoma bosci</i>		1	—	—	4	—	—	—	—
<i>Trinectes maculatus</i>		1	1	1	—	—	—	—	—

Ictalurus furcatus (LeSueur), Blue catfish.—Two specimens of this fresh-water catfish were taken. One measured 104 mm and was found at Mile 16 in a salinity of $1.0^0/_{00}$. The second, measuring 85 mm in length, was caught in a salinity of $10.4^0/_{00}$ at Mile 9. Gunter (1945) found a few blue catfish in salinities up to $6.9^0/_{00}$ in Copano Bay.

Syngnathus scovelli (Evermann and Kendall), Gulf pipefish.—In September 1956, 164 specimens were collected from two stations. Twenty-one came from a salinity of $38.1^0/_{00}$ at Mile 16 and 143 were found in a salinity of $17.4^0/_{00}$ at Mile 25. Nearly all the males were either carrying developing eggs and embryos or had recently delivered broods (as indicated by their enlarged, flaccid pouches). One other pipefish, a ripe female measuring 89 mm, was taken in a salinity of $0.06^0/_{00}$ during June 1957.

Pipefish are usually found in or near submerged vegetation, and salinity might well affect their distribution and abundance by altering the amount of vegetation available to them. Simmons (1957) found this species abundant in vegetation in salinities to $45^0/_{00}$.

Fundulus grandis Baird and Girard, Gulf killifish.—Forty-four Gulf killifish ranging in length from 21 to 90 mm were taken in salinities of 0.05 to $58.6^0/_{00}$. Table 2 shows that this species occurred throughout a wide range of salinity-temperature combinations. Small and large killifish were found together in both fresh and hypersaline water. Simpson and Gunter (1956) took *F. grandis* in salinities varying between $1.8^0/_{00}$ and $76.1^0/_{00}$.

Lucania parva (Baird and Girard), Rainwater killifish.—Seventy-four specimens ranging in length from 9 to 32 mm were collected in salinities from $0.05^0/_{00}$ to $47.6^0/_{00}$. Sixteen were taken at one station in a salinity of $38.1^0/_{00}$, and only four were caught in salinities above this. Over 60 percent were found in salinities less than $10.0^0/_{00}$.

Gunter (1945) found this species most abundant in salinities between $10.0^0/_{00}$ and $15.0^0/_{00}$. Kilby (1955) took 81 percent of his specimens from waters of $10^0/_{00}$ or less. Simpson and Gunter (1956) found 39.4 percent of the rainwater fish they collected in salinities below $10.0^0/_{00}$, the greater proportion having been taken at salinities between $18.4^0/_{00}$ and $48.2^0/_{00}$. In Florida,

Springer and Woodburn (1960) found this species to be most common in salinities greater than $25^0/_{00}$. They stated that vegetation rather than salinity is probably the most important factor affecting its distribution.

Cyprinodon variegatus Lacépède, Sheepshead minnow.—A total of 588 sheepshead minnows was collected, accounting for 18.5 percent of all fishes taken. They were found in salinities ranging from $0.05^0/_{00}$ to $58.6^0/_{00}$.

Simpson and Gunter (1956) caught 2,009 *C. variegatus* in a salinity of $142.4^0/_{00}$ and stated that, so far as they knew, "this was the highest salinity at which living fishes have been reported." During August 1957 the writer kept one specimen in a small aquarium for 7 days in a salinity of $125.2^0/_{00}$ and when the salinity was raised to $145.6^0/_{00}$ by the addition of sea-salt crystals, it lived an additional 37 hours. However, as Simpson and Gunter (*op cit*) emphasize, "water at such salinity is not sea water for some salts are precipitated before sea water attains such concentration and the salt complex is changed."

In December 1957 a pair of *C. variegatus* kept in an aquarium in the laboratory spawned four eggs. These eggs were transferred to a shallow glass dish 100 mm in diameter and filled with sea water to a depth of 25 mm. The dish was placed in a water-filled pan to avoid rapid changes in temperature and the eggs were observed daily. On the afternoon of the 12th day the eggs had not hatched, but on the morning of the 14th day three larval fishes were found darting rapidly around the dish. They measured 4 mm in standard length and had absorbed their yolk sacs. Evaporation had decreased the depth of the water in the dish to 8 mm and salinity was in excess of $110^0/_{00}$. Temperature during incubation ranged from 17.4°C to 27.5°C . Within the ranges recorded, increasing salinity and changes in temperature did not inhibit incubation of the eggs and young were able to survive in hypersaline water.

There appears to be no correlation between size and salinity as small and large specimens were found in all salinities encountered. Radical changes in abundance were not noted even during periods of extremes in salinity and temperature (Table 2).

TABLE 2.
Salinity-temperature conditions at three stations on the Aransas River and the number of individuals of several species taken therein.

Date	Station	Salinity ‰	Water temperature °C	<i>Fundulus grandis</i>	<i>Lucania parva</i>	<i>Cyprinodon variegatus</i>	<i>Mollienisia latipinna</i>	<i>Menidia beryllina</i>	<i>Mugil cephalus</i>
9/ 4/56	9	54.9	29.3	1	—	6	—	—	2
	16	38.1	27.9	3	16	90	95	76	8
	25	17.4	29.8	—	2	7	59	148	2
10/14/56	9	58.2	29.5	—	—	—	—	1	4
	16	54.0	28.0	—	—	3	—	2	—
	25	35.2	29.6	—	—	—	—	—	4
11/25/56	9	58.6	16.0	2	—	13	—	6	—
	16	52.2	16.0	—	—	8	1	31	—
	25	41.3	18.6	—	3	4	34	51	—
1/30/57	9	50.3	16.0	3	—	52	—	6	1
	16	43.9	20.5	—	—	62	—	1	2
	25	11.4	18.9	1	—	3	—	58	17
3/ 2/57	9	49.5	21.0	3	—	15	—	7	8
	16	39.0	21.2	1	—	17	—	9	16
	25	21.0	21.0	2	1	21	2	157	55
3/30/57	9	54.3	21.2	10	—	30	—	20	9
	16	47.6	21.2	—	2	47	—	11	11
	25	29.5	21.2	—	6	11	1	481	9
5/ 5/57	25	0.08	24.2	—	—	7	11	2	10
6/22/57	25	0.06	26.2	—	4	—	—	1	—
7/20/57	9	0.7	—	5	—	90	—	—	—
	16	0.5	—	—	—	4	—	—	—
	25	1.1	34.5	—	—	—	—	101	1
8/14/57	9	10.4	32.9	6	—	21	—	—	1
	16	1.0	31.2	—	—	7	—	5	—
	25	1.0	31.2	—	2	2	2	98	—
10/ 5/57	9	0.8	27.2	1	—	12	—	13	—
	16	0.06	27.0	—	—	5	—	6	—
	25	0.05	29.0	2	1	—	—	2	—
11/ 2/57	9	8.3	24.6	4	—	22	2	17	—
	16	2.7	24.5	—	—	12	—	23	—
	25	0.2	24.2	—	38	17	—	158	—

Gambusia affinis (Baird and Girard), Mosquitofish.—Thirty-three specimens from 9 to 36 mm long were collected. All but five were taken in salinities of 1.1‰ or less. In September 1946 four specimens were found in a salinity of 17.4‰. During November 1957 one mosquitofish measuring 19 mm was found in a salinity of 8.3‰ at Mile 9.

Simpson and Gunter (1956) caught one *G. affinis* in a salinity of 20.6‰. Kilby (1955) stated: "... it thus appears that the fish is most numerous in protected waters such as shallow pools and vegetated areas where the salinities are lowest, at least periodically, but it can tolerate salinities up to at least 26‰."

Mollienisia latipinna LeSueur, Sailfin molly.—Two hundred and seven individuals ranging between 12 and 44 mm in length were caught in salinities of 0.08‰ to 52.2‰. This species is ordinarily found in schools and thus capture is, for the most part, fortuitous. In fact, three seine hauls accounted for more than 90 percent of the specimens collected.

Herre (1929) noted the remarkable salinity tolerance of *M. latipinna* in populations which had been transported from the United States via the Hawaiian Islands and accidentally naturalized in the Philippine Islands. He found the species to be abundant in salinities from 32‰ to 87‰, and that the latter salinity appeared to be near

its limit of toleration, for in ponds with a salinity of $94^0/_{00}$, it had entirely disappeared.

Menidia beryllina (Cope), Tidewater silverside.—A total of 1,491 individuals was collected. The tidewater silverside is probably the most abundant species in the area sampled. They were found in salinities from $0.05^0/_{00}$ to $58.6^0/_{00}$ and in widely differing combinations of salinity and temperature. Collections taken over a wide range of salinities had both small and large specimens in fairly constant ratios. Gunter (1945) found specimens of *M. beryllina* to be slightly larger in waters above $25^0/_{00}$ than in those below that salinity.

Mugil cephalus Linnaeus, Striped mullet.—One hundred and sixty striped mullets were collected during this study. Adult mullets easily escaped the collecting gear used, and only six specimens captured were more than 100 mm long. The great majority were juveniles measuring 22 to 42 mm taken from March to May 1957. Juveniles were found in salinities ranging from $0.08^0/_{00}$ to $54.3^0/_{00}$. Larger mullets were observed jumping in the river during every month and in every salinity encountered. Mulletts at all ages are euryhaline.

Since it is difficult to separate immature *M. cephalus* and *M. curema*, it is possible that some of the smaller specimens were *M. curema*.

Mugil curema Valenciennes, White mullet.—One white mullet measuring 79 mm was taken at Mile 25 in a salinity of $0.2^0/_{00}$. Its fins were heavily infested with leeches.

Micropterus salmoides (Lacépède), Largemouth bass.—At Mile 25 on September 4, 1956 a largemouth bass 151 mm long was caught in a salinity of $17.4^0/_{00}$. Two other species of the family Centrarchidae and one cichlid species were included in this unusual collection. It is unfortunate that further salinity determinations for the upper reaches of the river were not made on this date to determine the salinities these typically fresh-water species passed through to reach this station. Hildebrand and Schroeder (1928) reported *M. salmoides* from a salinity of $12.87^0/_{00}$ taken at Lewisetta, Virginia, in August 1921. Of the 18 specimens reported in Kilby's (1955) collections, only 1 was taken where the salinity reached $11.8^0/_{00}$. Renfro (1959) concluded that salinities above $9^0/_{00}$ were progressively more critical, but that this species might

be expected to survive several weeks in lower salinities.

Chipman (1959) studied fishes in a Louisiana pond which was polluted with oil well brine wastes. He noted mortalities of fresh-water species which died during a 7-day period in which salinity was first recorded at $16.5^0/_{00}$, rose to $20.9^0/_{00}$ on the 5th day, declined to $5.8^0/_{00}$ and $6.6^0/_{00}$ respectively on the 6th and 7th days. He found one largemouth bass dead in a salinity of $20.6^0/_{00}$.

Chaenobryttus gulosus (Cuvier), Warmouth.—Two specimens measuring 68 and 72 mm taken in the collection mentioned above (salinity $17.4^0/_{00}$) were the only two warmouths observed.

During his 7-day study Chipman (1959) found 748 warmouths dead. He found in laboratory toxicity experiments that 12 specimens tested died in salinities between $10.7^0/_{00}$ and $16.9^0/_{00}$.

Lepomis macrochirus Rafinesque, Bluegill.—Six subadults were taken at Mile 25 September 4, 1956 in $17.4^0/_{00}$. On November 2, 1957 six young specimens 28 to 35 mm in length were collected at Mile 16 in $2.7^0/_{00}$. The remaining 43 bluegills taken were found in salinities of $1.1^0/_{00}$ or less and ranged in length from 16 to 83 mm. Chipman (1959) noted 523 dead bluegills during his 7-day study.

Lepomis megalotis (Rafinesque), Longear sunfish.—Four subadults were taken in collections during the latter half of 1957. All were caught in salinities of $0.2^0/_{00}$ or less.

Bairdiella chrysura (Lacépède), Silver perch.—Two specimens measuring 86 and 93 mm were taken on November 2, 1957 in a salinity of $2.7^0/_{00}$. Gunter (1945) found this species to be more or less indifferent to salinity. Kilby (1955) caught silver perch in salinities from $5.6^0/_{00}$ to $27.3^0/_{00}$. Springer and Woodburn (1960) took this species in salinities from $3.7^0/_{00}$ to $35.0^0/_{00}$ with most being captured in salinities above $20.0^0/_{00}$.

Eucinostomus argenteus Baird and Girard, Spotfin mojarra.—Three young individuals 40, 41, and 43 mm long were caught at Mile 9 in a salinity of $8.3^0/_{00}$. Species identification of this difficult genus is provisional.

Cichlasoma cyanoguttatum (Baird and Girard), Rio Grande perch.—Twelve Rio Grande perch were taken during the study,

four being found in the collection of September 4, 1956 at Mile 25 in $17.4^{\circ}/_{00}$. The remaining specimens were taken at various times in salinities of $1.1^{\circ}/_{00}$ or less.

Dormitator maculatus (Bloch), Fat sleeper.—One specimen 38 mm long was caught on September 5, 1956 at Mile 9 in a salinity of $54.9^{\circ}/_{00}$. As this species is known to penetrate far inland (Moore 1957) it appears to be tolerant to a wide range of salinities.

Gobiosoma bosci (Lacépède), Naked goby.—Five specimens were collected, three being taken in $21.1^{\circ}/_{00}$, one in $17.4^{\circ}/_{00}$, and one in a salinity of $0.2^{\circ}/_{00}$.

Trinectes maculatus (Bloch and Schneider), Hogchoker.—Three hogchokers were taken in salinities of $0.8^{\circ}/_{00}$, $2.7^{\circ}/_{00}$, and $8.3^{\circ}/_{00}$. Simmons (1957) stated that the hogchoker was common in salinities of $50^{\circ}/_{00}$ or less during the fall months in the Laguna Madre.

DISCUSSION AND SUMMARY

During this study salinity in the river varied over a broad range and fluctuations were sometimes rapid. Water levels were constant except during floods; water temperatures observed varied from 16.0° C to 34.5° C, and the shore and bottom configuration was stable. Most of the species taken were those which are characteristically found along the shoreline, and it must be emphasized that the conclusions reached do not extend to the fishes which were undoubtedly present in the river but which were not taken with the gear used.

As previously stated, the objective of the study was to note the occurrence of fishes in varying salinities. It is felt that the data obtained allow inferences concerning salinity tolerances. Salinity tolerance as here used is construed to be the capacity of a fish to endure specific levels of dissolved salts. The writer is aware that the relationship of a fish to its environment is a complex phenomenon. A fish is obliged to adjust not only to changing salinity, but to changes in temperature, dissolved oxygen concentration, food supply, and numerous other interrelated parameters of its environment. In the case of critical salinities (those concentrations of dissolved salts too low or high for the fish to withstand indefinitely) we might expect exposure time to become a factor. That is, in increasingly more critical salinities, the

fish's survival time must decrease. For this reason, it is possible that some of the fishes taken were transients, being found in salinities higher or lower than they could withstand for more than limited intervals.

Twenty-six species belonging to 8 orders and 16 families were collected. Nine species (*Dorosoma petenense*, *Notropis lutrensis*, *Ictalurus furcatus*, *Gambusia affinis*, *Micropterus salmoides*, *Chaenobryttus gulosus*, *Lepomis megalotis*, *Lepomis macrochirus*, and *Cichlasoma cyanoguttatum*) are fresh-water fishes, i.e., they are found in fresh water and occur in salt waters only occasionally or in reduced numbers. Five of these species were found in a salinity of $17.4^{\circ}/_{00}$, which indicates that they have at least temporary tolerance to this salinity.

Why then do not these fresh-water fishes occur in greater numbers when the salinity in the river has been decreased to a level which they are known to tolerate? Probably they do not because of the innate characteristics of this particular hydrographic system. When salinity is lowered these fishes venture into the lower reaches of the river. Before their numbers can reach significant proportions, however, the salinity begins to increase and they are either forced back upstream or perish. Population densities of these "fresh-water" species appear to vary inversely with salinity.

The gar, *Lepisosteus spatula*, and the clupeid, *Dorosoma cepedianum*, were tolerant of all salinities observed and might well be considered euryhaline. Presumably spawning must take place in fresh water.

Eight species (*Brevoortia patronus*, *Anchoa mitchilli*, *Syngnathus scovelli*, *Bairdiella chrysura*, *Eucinostomus argenteus*, *Gobiosoma bosci*, *Trinectes maculatus*, and *Mugil curema*) are commonly found during part or all of their lives in salinities between fresh water and sea water. With the exception of the goby, all enter the Gulf at times. However, these species are probably not well adapted for life in salinities above $35^{\circ}/_{00}$.

The remaining seven species (*Fundulus grandis*, *Lucania parva*, *Cyprinodon variegatus*, *Mollienisia latipinna*, *Menidia beryllina*, *Mugil cephalus*, and *Dormitator maculatus*) are particularly fitted for life in a wide range of salinities. They are able to maintain their populations in the river regardless of changes in salinity. Most of these species

were represented in collections in which salinity and temperature were at extreme levels. They are among the hardiest of the smaller fishes found along the coast of the Gulf of Mexico. These are the fishes found most often and in greatest abundance along the shorelines of inside waters of the northwestern Gulf of Mexico.

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ABSTRACT

Fishes were collected at three stations on the Aransas River, a non-flowing, normally brackish body of water on the Central Texas Gulf Coast. A drought prevailing during the first half of the study produced a highly saline environment. Subsequent rainfall and lowered salinities provided an opportunity to note the occurrence of fishes taken at three stations over a wide range of salinities. Twenty-six species are categorized as to their salinity tolerance. Five species of fresh-water fishes were found in a salinity of 17‰. Seven species were found to tolerate salinities ranging from nearly fresh to well above 45‰.